



A Changing Climate: Consequences for Subsistence Communities

By Don Callaway

Evidence of rapid climate change is extensive throughout the arctic region and is posing substantial problems for sub-

sistence users in Alaska. Increasing mean temperatures, increasing levels of carbon dioxide (CO₂) in the atmosphere, melting permafrost, changing habitat as the boreal forest moves north and a dramatic retrenchment in sea ice coverage all have enormous impacts on subsistence resources, which in turn have had many detrimental outcomes for subsistence harvesters.

Temperature

For Alaska and western Canada, the average mean winter surface air temperature has increased by as much as 5° to 7°F

(3° to 4°C) over the last 60 years (*Figure 2*), which is, as the literature predicted, about triple the change experienced at the equator. This large observed warming trend has been accompanied by increased in precipitation of roughly 30% between 1968 and the 1990s.

Changing Habitat—Land

Boreal forests are expanding north at the rate of 62 mi (100 km) for every increase of 1.8°F (1°C) in air temperature. Predictions are that in the next 100 years the Seward Peninsula will have a transition from a primarily tundra ecosystem to one of white spruce and deciduous forest. Certain important subsistence species, like caribou, will likely disappear during this transition. For caribou herds in the state as a whole, caribou population dynamics may reflect non-linear dynamic systems and, as such, are difficult to predict given that slight changes in initial conditions can have profound outcomes as they are iterated throughout the system. Current analysis of the impacts of climate change on caribou populations covers the entire gamut of

impacts. Some analysts see increased precipitation creating icy crusts on the snow during the winter, making “cratering”, caribou efforts to remove snow to access calorie rich mosses and lichens, taking a couple of hours rather than a few minutes. These energy expenditures will dramatically increase probability of winter starvation and high calf mortality. Decreased spring body fat of females will significantly reduce lactation and therefore calf survival rates. There are also concerns that longer and hotter summers will increase insect harassment on the calving grounds (*Gunn et al. 1998*).

In contrast, Brad Griffith’s research on the Porcupine Caribou herd seems to indicate warmer temperatures lead to an earlier green-up on calving grounds (*Griffith et al. 2002*). Quicker growth of vegetation provides increased nutrition for cows and increased milk production for the young. Half of all caribou deaths are from calves that die in June, but these habitat changes have increased overall survival rates. Griffith is aware of the downside of increased snowfall and rain in winter and is now trying to incorporate both factors in his

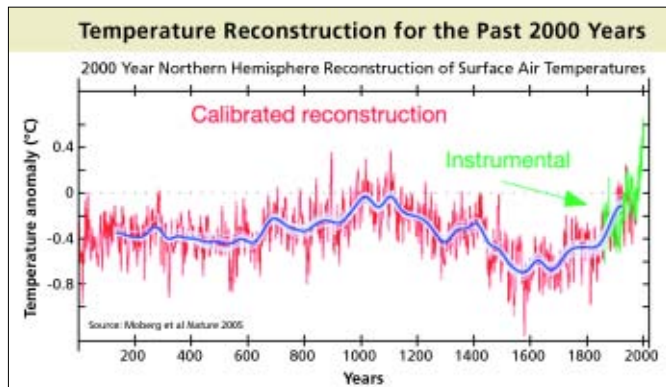


Figure 2. Alaska and Western Canada, the average winter temperatures have increased by as much as 3° to 4°C over the past 60 years, which is a significant increase given that the global increase over the past 100 years has been only about $0.6^{\circ} \pm 0.2^{\circ}\text{C}$.

Figure 1. (Left) Barrow hunter Carl Kippi with two ringed seals that he has harvested.

Photograph courtesy of North Slope Borough, Department of Wildlife Management

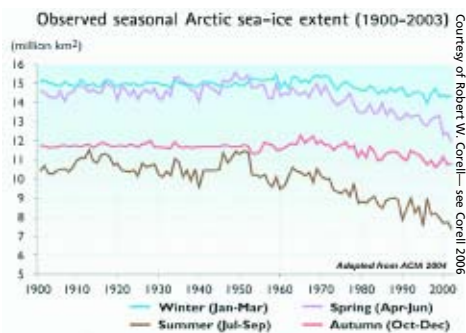


Figure 3.

model. Compounding the difficulty of these estimates is the fact that increased spring precipitation makes it more difficult for caribou to migrate, with dramatic increases in calf mortality as they forage swollen rivers.

For forests in general the increased warming trend has brought about a 20% increase in growing days. However, there are also contrary indicators of increased pest disruption and fire frequency with some models indicating a 200% increase in total burn area per decade. All these factors impact habitat which in turn impact the distribution, density and availability of subsistence resources.

Sea Ice

Arctic summer (July–September) sea ice has decreased from about 4.5 million mi² (11.8 million km²) in 1900 to an area of about 2.8 million mi² (7.3 million km²) in 2004 (Figure 3). This contraction represents about a 40% decrease in sea ice surface area. The sea ice provides habitat for seals, for polar bears that prey on the seals and for subsistence hunters which harvest both resource categories. During the summer, the ice edge is a particularly rich environment

with nutrient mixture in the water column providing subsistence and florescence for the whole food chain from phytoplankton to fish, to seals, walrus, whales and human hunters. The decreasing sea ice truncates the available ice margin, which in turn decreases the rich habitat lowering the populations of the complex chain of species that depend on that habitat, e.g. walrus. Other deleterious outcomes include:

In 1998 a spring break up in the Beaufort Sea that was approximately three weeks early interrupted the ringed seal mother-pup nursing period. Ringed seals depend on the stable ice for their lairs and for a successful nursing period (typically six weeks). Wasted, skinny and stunted seal pups were found, by scientists and seal hunters. It is unclear the long term affects on ringed seal population, but interpolation indicates a decreasing population.

This will have a direct impact on polar bears, where ringed seals are an important part of their diet—a three year decline in ring seal productivity in the 1970s was reflected in poor condition and lower productivity in polar bears. In addition, recent surveys indicate polar bears having to swim much further in the fall to reach the polar ice cap, which is their most productive hunting habitat. Some have drowned in transit (perhaps due to rough seas) but almost all arrive with decreased and stressed energy budgets. Decreasing ring seal populations will also directly impact Iñupiat hunters who harvest ringed seal in substantial quantities.

Early spring breakup due to climate change and reduced sea ice area (Figure 5) has other direct consequences for Iñupiat

marine mammal hunters. A recent study of whaling captains on the North Slope of Alaska indicates: whales arrive earlier, leads are wider, whales are further out, first year shore ice is brittle and difficult to find haul outs to process whales, new base camp locations must be found because of changing ice conditions, more dangerous open and rougher water, more boats are needed for safety reasons, bigger more expensive motors are needed, and more fuel is needed in a time of rising fuel prices.

More subtly it has been discovered that storm surges coming from the west towards the Alaska coastline pick up considerably more energy as they move across open water (which acts as a thermal storage for sunlight) than it does from pack ice (which by reflecting sunlight has lower thermal storage).

Storm Surges

A recent General Accounting Office report found that 90% of Alaska's 213 predominantly Native villages, which are historically situated along rivers and coasts, are affected regularly by floods or erosion (U.S. Senate 2004). Global warming and concomitant changes in the climate have exacerbated these problems. Melting permafrost (see **Thawing Permafrost** below) is more prone to erosion, and in addition, barrier sea ice is coming later in the year leaving coastal villages such as Shishmaref and Kivalina vulnerable to the increasingly violent fall storms. Coastal villages are also increasingly susceptible to flooding as sea levels rise due to thermal expansion and other factors. Combating eroding community infrastructures takes time and labor away from subsistence activities. In addi-

tion, the personal and household costs of eroded food caches and housing reduces already decreasing (in constant dollars) household incomes that must be used to purchase subsistence technology (equipment and supplies needed to access and harvest wildlife, fisheries, and plant materials), technology that is wearing out faster as subsistence hunters have to travel further to obtain game. Rural subsistence communities located along rivers also face increased risk from flooding as precipitation regimes fluctuate throughout interior Alaska.

Two communities illustrate the costs of resolving these problems and the profound threats to subsistence activities. Shishmaref's relocation costs have been estimated to be up to 1 million dollars per household. Here are the cost breakdowns for the four alternatives currently being considered:

Alternative One: move the entire community, of approximately 142 households, east to the mainland for a total cost of about \$179 million. The costs include: \$20 million to move 150 homes, \$26 million to move or build a school, clinic, and city hall, \$25 million for a new airport, \$23 million for roads, and \$25 million for water treatment and sewage.

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Alternative Two: relocate all 142 households to Nome—approximate cost of \$93 million.

Alternative Three: relocate everyone to Kotzebue—approximate cost of \$93 million.

Alternative Four: the community stays in place on Sarichef barrier “island” but fights the erosion with shield rock and other means—total cost \$109 million.

Much further south in the Yukon/Kuskokwim area is the community of Newtok with about 65 households. This community has experienced 4,000 ft (1,200 m) of erosion and loses about 90 ft (27 m) of shoreline per year. Estimates indicate that land under the community will erode in the next five years. Relocation costs, including emigration to a nearby site or transplanting all the households to Bethel or Hooper Bay, are estimated between \$50-100 million. Some of the relocation alternatives for both communities contain: loss of access to traditional use areas for subsistence activities, loss of history and sense of intact community, and potential loss of social networks and extended kin support integral to sustaining traditional culture.

Thawing Permafrost

Borehole temperature logs indicate that near-surface permafrost of the Alaska Arctic Coastal Plain and Foothills has warmed approximately 5°F (3°C) since the late 1980s (McGuire 2003). We have already discussed the impacts of storm surges on Shishmaref, however, the thawing permafrost exacerbates the affects of these storms by making the shoreline more

vulnerable to erosion. In addition, the discontinuous permafrost is warming at about 0.36°F (0.2°C) per year which is causing wide spread thawing and extensive areas of subsidence. This subsidence is severely affecting buildings and infrastructure such as roads.

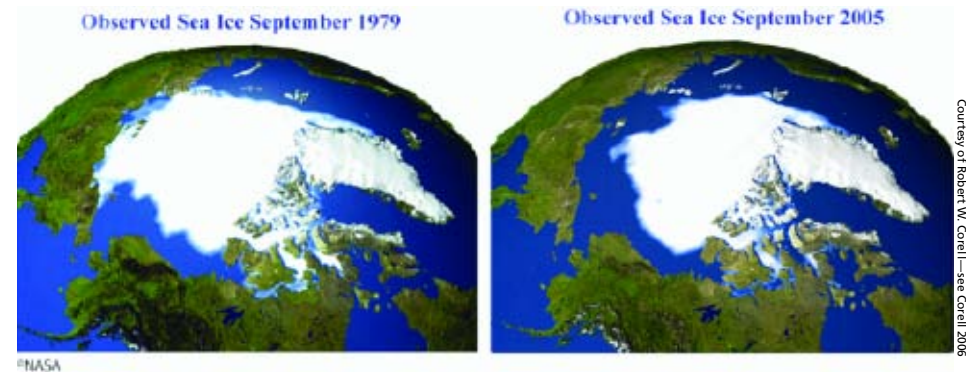
How do climate change impacts to urban Alaska infrastructure affect subsistence in rural Alaska? Revenue flows to rural Alaska have experienced sharp declines during the last decade. The urban-dominated Alaska legislature, facing decreasing revenues from oil remittances, has cut programs and monies to rural communities, e.g., school maintenance. Almost all of the employment in rural community comes from federal or state programs, such as part-time employment on capital improvement projects. In some communities, perhaps half the household income is used to purchase subsistence technology. A shrinking revenue flow is already becoming more constricted as the state legislature apportions more and more dollars to sustain urban infrastructure. For example, some roads in the Fairbanks area have to be continually rebuilt due to the impact of thawing of permafrost. Thus, rural communities face a triple whammy from thawing permafrost: 1) coastal communities experience accelerated erosion, 2) there is less or no money to mitigate infrastructural decay, and 3) sharp decreases in employment and wage opportunity decrease available income for subsistence technology in an era where hunters must spend more money on such technology to access and harvest wildlife resources (see **Fisheries** below).

A recent four year study by Brian Riordan of the Bonanza Creek Long-Term



Photograph courtesy of North Slope Borough, Department of Wildlife Management

Figure 4. Bowhead whale being processed by residents of the North Slope Borough.



Courtesy of Robert W. Corell—see Corell 2006

Figure 5. Arctic sea ice is at its minimal extent in September. These two photos, reconstructed from NASA data, show the sharp contrast in sea ice retreat by 2005, the lowest concentration on record.

Ecological Research Program at the University of Alaska, Fairbanks compared black-and-white aerial photographs from the 1950s, color infrared aerial photographs from 1978 to 1982 and digital satellite images from 1999 to 2002. Riordan con-

cluded that 50% of the ponds in subarctic boreal regions have disappeared in the last 50 years. Much of the remaining ponds have shrunk. These ponds are usually formed when depressions in the ground are filled with rain water but are unable to

drain due to the fact they are underlain with impenetrable permafrost. Melting of the permafrost lets these ponds drain.

There are at least two important consequences of these disappearing ponds. First, the ponds provide prime habitat for migratory waterfowl, a much anticipated spring subsistence resource. Second and more ominous, the drying landscape may release more carbon dioxide into the atmosphere, further contributing to atmospheric warming, as the carbon stored in the normally wet soil decomposes.

Fisheries

Climate change impacts on fish stocks is extremely complicated. Changes in the velocity and direction of ocean currents affects the availability of nutrients, and in addition, for salmon, freshwater stream temperature and flow can be key indicators for survival and recruitment. To this point, warmer sea surface temperatures and lower ice coverage (since the regime shift in 1975)

have had positive outcomes for pollack and flounder, while salmon, with a narrow range of tolerance for temperature shifts, have had record runs in some areas (e.g., Kodiak) while other stocks in western Alaska, the Pacific Northwest and Canada have experienced substantial decreases (Weller *et al.* 1999, Criddle and Callaway 1998).

Thus, while the Yukon and Kuskokwim Rivers sustained drastically low runs during the last decade, and the state designated many communities from these areas as economic disasters, Copper River runs of sockeye in Southeast Alaska were extremely strong at 1.7 million fish. The strong run in this area maybe linked to the fact that these stocks are independent from Bristol Bay and Bering Sea stocks. Also very disturbing is recent research that ties climate change to increased parasitism in Yukon River salmon. One research project estimates that more than a quarter of Yukon River salmon are being parasitized by *Ichthyophonus*, a disease organ-

ism that prior to 15 years ago “had never been recorded in salmon anywhere except by artificial transmission” (Kokan and Hershberger 2003).

Commercial fishing is intrinsically linked to subsistence fishing in that subsistence fish are often taken during commercial fishing activities, and the profits from commercial fishing often help to pay for the technology (boats, outboard motors, guns, snow machines, all-terrain vehicles) necessary to perform subsistence activities.

For example in Unalakleet in 1982, where wildlife resources comprise about 75% of the local diet, the primary source of income for about 115 Alaska Natives was commercial fishing. During this period the average household income was \$20,100 per year while the average household cost for subsistence equipment and gas might run \$10,000, or nearly half the total household income. One study, Wolfe (1984:176) indicated that households in the lower Yukon region might average a harvest of

10,000 pounds of salmon, 90% of which might be sold with the remaining 10% retained for subsistence use.

In the last decade changes in the commercial fisheries have had substantial economic stress on Bering Sea communities. However, as Jorgensen (1990:127) notes: When, in 1982, late breakup and very high water destroyed the salmon fishing for Yukon River villages, Unalakleet families connected to families along the Yukon River through marriage packed and shipped huge quantities of fish, caribou, and moose to their affines. (For a more detailed discussion, see Callaway *et al.* 1999).

However, climate change, even independent of its impacts on fisheries stocks, can have important implications for subsistence fishing. Alex Whiting, a member of the Qikiktagrugmiut in Northwest Alaska, discusses the cultural impacts of late freeze-up on his community. He notes that the youth and elderly depend on strong ice in fall to ice fish for saffron cod and smelt. Late freeze up and a concomitant shorter ice fishing season constrains the interactions of elders and youth during one of their few independent subsistence pursuits and lessens the opportunity for elders to pass on traditional knowledge and ethical values (Whiting 2002, Huntington and Fox 2005).

Winners and losers

Changing climate always brings new winners (pollack, flounder) and new losers (herring, crab, some seal and whale species). Alex Whiting also details the mixed outcomes from these changes for the Qikiktagrugmiut, who reside in the area we now know as Kotzebue—on the plus side



Courtesy of Tony Weylounna, Kaveak Transportation Program—see RISA 2004

Figure 6. Two photos of a coastal road in the community of Shishmaref. The first photo was taken around 12:30 pm on October 8, 2002 while the second photo was taken some two hours later. During that period the shoreline had eroded through the road (notice the tire tracks).

he enumerates: better whitefish harvest, better clamming (due to storm surges), better spotted seal hunting, better access to caribou by boat (less by snow machine), better arctic fox harvests, and better access to driftwood. He considers the negative impacts to be: shorter ice fishing season, poor access to Kotzebue for people living outside, rough ice conditions, more danger from thin ice, more erosion and flood problems, and loss of traditional ecological knowledge specific to seal hunting in leads.

Social and Cultural Impacts of Climate Change

The repercussions from climate changes on indigenous arctic communities can be enormous. To this point indigenous institutions seem to be dealing with the changes and deprivations that climate changes seem to be bringing to

subsistence activities. Extended social networks based on kinship seem to be buffering the impacts of these changes through wide spread sharing of resources, technology, labor, cash and information (*see Callaway 2003*). However, more drastic impacts from storm surges or flooding may require whole communities to relocate. Previous research indicates some of the trauma of such actions—decision making within the community is often turned upside down as elders and political leaders find themselves in a completely different context. Hunters esteemed for their abilities and willingness to share are removed from the landscape to which their knowledge is linked. These processes can lead to a pervasive sense of helplessness and lack of control, which can have many social and psychological consequences such as increased levels of drinking and violence.

More ominous concerns, not discussed in this article, are the potential for more systemic impacts to entire ecosystems. Marine productivity, biodiversity and biogeochemistry may change considerably as oceanic pH is reduced through oceanic uptake of anthropogenic CO₂. Increased acidity may impact and eliminate the productivity of phytoplankton, the very basis of the oceanic food web. At the far end of the impact spectrum are suggestions that ancient mass extinctions are correlated with an oxygen depleted ocean spewing poisonous gas as a result of global warming (*Ward 2006*). Certainly communities dependent on subsistence activities are currently bearing the brunt of climate change and are struggling to adapt to rapidly changing and fluctuating conditions. However, in the not too distant future we all may be taxed beyond our abilities to cope.

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